THE FOSSIL LAND SHELLS OF BERMUDA.[1]

BY ADDISON GULICK.

Last summer (1903), through advantages offered by the new Biological Station in Bermuda, I was able to collect the shells on which this paper is based. In the study of the material I owe much to Dr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia.

It will be necessary in the discussion of the fossils to compare them with the species that are now native, in the looser sense, to the islands. In drawing the line between these and the snails supposed to have been brought by commerce, I shall follow Dr. Pilsbry's latest paper on the "Air-breathing Mollusks of the Bermudas."[2] I shall also rule out all the littoral species, including *Truncatella*, because the fossil beds were not situated where such shells could be expected.

The most unsatisfactory feature of work on Bermudian fossil land shells is the difficulty in determining the ages of the various deposits. The rock of Bermuda is exclusively solidified dunes of calcareous sand, and the soil is the rust-colored residue of the weathered rock. In weathering, the surface of the rock becomes completely broken up into pockets and crevices packed with the earth. It is estimated[3] that every inch of earth must represent eight or nine feet of rock eroded, and thus when it is possible to judge of the average depth of soil formed over a deposit, that depth can be made an index of the age of the deposit.

Probably the oldest good fossiliferous deposit that I examined is collecting locality No. 807 (see Map No. 3) of the Bermuda Biological Station, at a hard-stone quarry on the west side of Knapton Hill, about midway between Hotel Frascati and "Devil's Hole." At this point a layer of eight or ten inches of red earth containing shells was covered by an ancient dune. The dune has become hard limestone, and its top has been eroded until now the red earth in its pockets must represent a layer averaging not less than six inches in thickness. The series of *Pœcilozonites* that we took from this bed is very incomplete, and the fossils of all the genera are poorly preserved, but notwithstanding this we are able to recognize at least eleven species and sub-

[1] Contributions from the Bermuda Biological Station for Research, No. 2.
[2] *Trans. Conn. Acad.*, Vol. X.
[3] A. E. Verrill, *Trans. Conn. Acad.*, Vol. XI, p. 490.

species. These are enough to identify its fauna with that of another deposit, locality No. 806 (see Map No. 2), where the shells are abundant and well preserved, but with no external evidence by which to estimate their age. This locality is another hard-stone quarry, where the excavations have uncovered a number of crevices and a cavern of considerable size. The shells are in stalagmitic conglomerate at the mouth of the cavern, and in the crevices, and also in the earth that fills certain of the pockets. They may represent a considerable period of time, but there is no way to distinguish any difference in age.

Another deposit at the same locality as the one last mentioned is a horizontal band of slightly reddish rock about half-way up the face of the quarry, and from two to three inches thick. This is part of the rock out of which the cave and pockets were eroded, so that the shells here are very much older than the others at No. 806; but here, again, there is no basis for a comparison with the date of No. 807. The remains here are obscure casts of *Pœcilozonites circumfirmatus* and of what appear to be *Vertigo* and *Carychium*.

I collected from three other beds in this neighborhood what seem to represent the same formation as the pockets of No. 806.

The first of these, locality No. 814, is a newly opened quarry just south from Coney Island. A red-earth pocket here contained a fine series of *Pœcilozonites nelsoni*, very large, but wanting the most extreme examples of both the elevated and the depressed variations. There are also fossiliferous conglomerates in caverns at this quarry, but they are composed of gravel too fine to contain *Pœcilozonites nelsoni*.

The best fossil specimens of *Pœcilozonites reinianus* came from locality No. 815, near Harrington House. They are noticeably larger than the recent specimens. No. 816, near 815, but on the shore of Castle Harbor, has large numbers of *Pœcilozonites bermudensis zonatus* and *Pœcilozonites reinianus*, the former associated with *Pœcilozonites nelsoni* in a conglomerate.

Bifidaria rupicola, found in the red earth of No. 806, may perhaps be an importation subsequent to the formation of No. 807, and *Strobilops hubbardi*, found at the same place, possibly may not have been a permanent resident; but we can safely assume that all the other species from the above localities belong to the epoch of the red-earth streak at No. 807. The remaining three deposits from which I collected are clearly much more recent than No. 807. These are in sand pits, in the nearly pure sand of partially solidified dunes. None of them have any clear signs of red earth, either about them or overlying them.

The shells at these places are so perfectly preserved that even the term "semi-fossil" seems a misnomer for them. Probably the sand preserves them by saturating the water with lime before it reaches them.

One of these shell deposits, locality No. 818, on the land of Mr. Benjamin Trott, in Tucker's Town, is only from 8 to 36 inches below the surface. The *P. nelsoni* were mostly in the upper foot of the deposit, where the bank is thoroughly solidified by the rain; but a few inches lower the sand is still loose enough to be scraped out with a strong hoe.

The two localities last to be mentioned, Nos. 808 and 809, are essentially alike. They face the Devonshire marshes on the northwest side—808 near the north end and 809 close to the barracks. The sand in these dunes appears to have drifted from near the present line of the north shore—a consideration which may yet give a clue to their age.

The following are my records of fossil and semi-fossil shells in these localities:

Locality 807.

PŒCILOZONITES NELSONI.
" NELSONI CALLOSUS.
" CIRCUMFIRMATUS, } Intergraded.
" DISCREPANS. }
EUCONULUS TURBINATUS.
ZONITOIDES MINUSCULUS.
" BRISTOLI. One specimen.
THYSANOPHORA HYPOLEPTA.
SUCCINEA BERMUDENSIS.
VERTIGO NUMELLATA.
" MARKI?
CARYCHIUM BERMUDENSE.

Casts in the Rock, Locality 806.

PŒCILOZONITES CIRCUMFIRMATUS.
VERTIGO.
CARYCHIUM?

Cave and Pockets, Locality 806.

PŒCILOZONITES NELSONI. Both extremes in height of spire.
" BERMUDENSIS ZONATUS.
" REINIANUS.
" CIRCUMFIRMATUS.

PŒCILOZONITES CUPULA.
EUCONULUS TURBINATUS.
THYSANOPHORA HYPOLEPTA.
SUCCINEA BERMUDENSIS.
STROBILOPS HUBBARDI.
BIFIDARIA RUPICOLA. One specimen.
VERTIGO NUMELLATA.
" MARKI.
CARYCHIUM BERMUDENSE.

Locality 814.

PŒCILOZONITES NELSONI, } In one pocket.
" REINIANUS. }
" NELSONI. In crevices.
" BERMUDENSIS ZONATUS, }
" REINIANUS, } In stalagmitic conglomerate.
" CIRCUMFIRMATUS, }
EUCONULUS TURBINATUS. }

Locality 815.

PŒCILOZONITES BERMUDENSIS ZONATUS? Small fragments only.
" REINIANUS.

Locality 816.

PŒCILOZONITES NELSONI.
" BERMUDENSIS ZONATUS.
" REINIANUS. (None kept in the collection.)
EUCONULUS TURBINATUS.

Locality 818 (Sand Pit).

PŒCILOZONITES NELSONI CALLOSUS.
" REINIANUS.
" DISCREPANS.
EUCONULUS TURBINATUS.
ZONITOIDES BRISTOLI.
SUCCINEA BERMUDENSIS.
BIFIDARIA SERVILIS. One specimen.
CARYCHIUM BERMUDENSE.

Locality 808 (Sand Pit).

PŒCILOZONITES BERMUDENSIS ZONATUS.
" REINIANUS.

PŒCILOZONITES CIRCUMFIRMATUS.
EUCONULUS TURBINATUS.
SUCCINEA BERMUDENSIS.
BIFIDARIA RUPICOLA. One specimen.
CARYCHIUM BERMUDENSE.
(POLYGYRA MICRODONTA? One immature specimen, which may have crawled into the sand in recent times. We shall give it no further notice.)

Locality 809 (Sand Pit).

PŒCILOZONITES BERMUDENSIS ZONATUS.
" REINIANUS.
" CIRCUMFIRMATUS. (None kept in collection.)
SUCCINEA BERMUDENSIS. (None kept in collection.)
CARYCHIUM BERMUDENSE.
PUPOIDES MARGINATUS. One specimen.

These lists include all the known fossils except *Pœcilozonites dalli.*

Outside of *Pœcilozonites,* the species that do not appear in deposit No. 807 are:

STROBILOPS HUBBARDI.
BIFIDARIA RUPICOLA.
" SERVILIS.
PUPOIDES MARGINATUS.

The last two of these appear only in the sand pits, and are in all probability later importations. The first two, found at No. 806, may also have arrived after No. 807 was covered up, but the fossils at No. 807 are so poorly preserved that we cannot presume upon the absence of these species. Ignoring these doubts, we may combine and rearrange the lists from Nos. 807 and 806—the more ancient fossils—mentioning after each species the habitat of its nearest relatives in other countries, as follows:

PŒCILOZONITES NELSONI.
" NELSONI CALLOSUS.
" CUPULA.
" BERMUDENSIS ZONATUS.
" REINIANUS.
" CIRCUMFIRMATUS.
" DISCREPANS.

EUCONULUS TURBINATUS.
ZONITOIDES BRISTOLI.
VERTIGO NUMELLATA. } Eastern North America.
" MARKI.
CARYCHIUM BERMUDENSE.

[4]ZONITOIDES MINUSCULUS. North America and West Indies.
[4]BIFIDARIA RUPICOLA. Florida, Cuba.
[4]STROBILOPS HUBBARDI. Florida, Jamaica.
THYSANOPHORA HYPOLEPTA. West Indies.
SUCCINEA BERMUDENSIS. West Indies.

Total, 17 forms, 14 of them probably peculiar to Bermuda. For comparison we have the following *recent* species, supposedly not imported by man:

PŒCILOZONITES BERMUDENSIS,
" REINIANUS,
" CIRCUMFIRMATUS,
[5]ZONITOIDES MINUSCULUS, } Remnant of the fossil fauna. Seven species.
THYSANOPHORA HYPOLEPTA,
SUCCINEA BERMUDENSIS,
[5]BIFIDARIA RUPICOLA.

[5]PUPOIDES MARGINATUS. North America, West Indies.

[5]THYSANOPHORA VORTEX,
[5]POLYGYRA MICRODONTA,
[5]BIFIDARIA SERVILIS, } West Indies. Five species.
[5]BIFIDARIA JAMAICENSIS,
HELICINA CONVEXA.

Total, 13 species, 6 of them probably peculiar to Bermuda.

Dr. Pilsbry's conclusion, from the anatomy of *Pœcilozonites*, that the oldest importations to Bermuda came from continental America, is thus confirmed by a large majority of the fossil forms. Bermuda, at the time of the No. 807 deposit, was characterized by not less than five genera of continental affinities, of which at least one had been resident long enough to have developed new generic characters and a respectable diversity of species. The abundance of the individuals, too, and the size and variability of some of the species, seem to show that the island was not inhospitable to continental genera at that epoch. There were not only the large extinct species *Pœcilozonites nelsoni* and *Pœcilozonites cupula*, but larger varieties also of *Pœcilozonites bermudensis* and

[4] Species not peculiar to Bermuda.
[5] Species not peculiar to Bermuda.

Pœcilozonites reinianus than are now living. The largest specimens even of *Pœcilozonites circumfirmatus* and *Succinea bermudensis* are among the fossils. These snails must have found more food than there is now on the uncultivated ground. There is also geologic evidence that they belonged to a more prosperous epoch than the present. Prof. Heilprin reports that in excavations for one of the docks, specimens of *Pœcilozonites nelsoni* were brought up from a peat deposit at a depth of forty feet below water. A rise of the land sufficient to put these shells ten feet above sea-level (see Map No. 1) would multiply the land area eight or ten times, changing it from a narrow ridge, hardly two miles wide at its widest, into an elliptical area, including, it is true, some large lagoons, but in all about ten miles across and more than twenty miles long. A large, protected interior valley would then receive the fertile soil that is now washed into the lagoon by every storm. It would not surprise me if the deposits at locality 807 should be shown to date from the period of this Greater Bermuda, but a person need hardly wait for this proof before supposing that the indigenous contemporaries of *Pœcilozonites nelsoni* were also characteristic of Greater Bermuda.

In spite of their evident prosperity, I do not think it could be proved that these snails lived under any densely shading vegetation. The humidity at Bermuda makes such a shade less necessary for snails than it is in many places. I have often seen *Succinea bermudensis* clinging to grass and to trunks of trees in such situations that I imagine an American summer day would have desiccated them. The tract about Prospect Hill (No. 809) must have been desolate, unshaded land when the hills were growing dunes, yet the sand here (localities 808 and 809) contains numerous well-developed specimens and quite a variety of species. These must either have lived where they are found, or else have been blown there from some place almost equally wind-swept.

The extinction of species that were able to prosper on those barren parts of the island seems to me a strange occurrence. If, as I believe is probable, the sand for these dunes came from near the present north shore, then the island must have had very nearly its present shape and size when these snails were alive. Thus when the Greater Bermuda sank, the change seems to have set new dunes in motion across this section of the Lesser Bermuda; and *Pœcilozonites zonatus*, *Carychium bermudense* and *Euconulus turbinatus* not merely survived the subsidence, but even formed a considerable population on the parts of the remaining island that were most damaged by the changing condi-

tions. How many other species still survived in the less altered sections it is impossible to say. It is hardly possible to prove that even the set of fossils from No. 806 belong to any earlier date. Indeed we might draw an analogy between *Bifidaria rupicola* at No. 806, which may be one of the later arrivals, and *Bifidaria servilis* at No. 818 and *Pupoides marginatus* at No. 809, either of which we can hardly hesitate to treat as recent arrivals. But however this may be, the sand-pit deposits are against the supposition that the *Carychium* and its hardier associates were exterminated merely by the increasing barrenness of the island. We should be in a better position to discuss the other causes if we knew whether these species survived till after the West Indian arrivals had begun to take possession of the land. The West Indies snails, especially *Polygyra microdonta*, of Bahama, are at present much the commonest of the "native" snails, and it may be that their special fitness for the more barren land of the new Bermuda made them deadly competitors to the old species. The newer formations at the west end of the islands, which I had not the time to visit, may perhaps be the ones in which to look for evidence on this question.

Notes and Descriptions.

Thysanophora vortex Pfr.

Living animals quite abundant under stones; but I looked in vain for fossil specimens. Greater Antilles, Bahamas, Southern Florida.

Thysanophora hypolepta 'Shuttl.' Pils.

I found more examples of this than of *Z. minusculus* among the fossils, but among the living snails *Z. minusculus* seems to be far more abundant. It is supposed to be indigenous.

Polygyra microdonta Desh.

Excluding importations from Europe, this species is the one now most in evidence. It is partial to the coarse native grass, but is to be found almost everywhere. I was surprised not to find any indubitable specimens of this in the sand pits. I hope other collectors will look for it. Bahamas.

Strobilops hubbardi Brown.

An adult and an immature specimen, from locality 806. The adult is somewhat larger than the usual size on the continent. Alt. 1.2, diam. 2.8 mm. Habitat, the Gulf States and Jamaica.

Vertigo numellata n. sp. Pl. XXXVI, fig. 6.

Shell rimate, minute, elliptical or bluntly pupiform, yellowish-corneous, faintly striate, of 5 rather convex whorls; the diameter through the body whorl not much greater than that through the whorl

preceding. A prominent, whitish, inflated ridge, appearing like a second peristome, occurs behind the peristome. Aperture proportionately more contracted than that of *V. ovata;* set with a parietal, an angular and a columellar lamella; and with two palatal and a basal fold. The palatal folds are prominent, the upper one slightly double-topped, the lower one more immersed and entering spirally. The parietal lamella is stout and blunt; the angular lamella smaller and thinner; the columellar lamella and the basal fold low and blunt. Peristome rather thin, expanded, and notched opposite the upper palatal fold, as in *V. ovata.*

Alt. 1.7, diam. .9 mm.

In one specimen there appears a slight suprapalatal denticle. A considerable number of smaller, more globose specimens seem to belong to this species. One of these from locality 806 measures 1.4 x .9 mm.

I have assumed that this species is more closely related to *V. ovata* than to any of the species reported from the West Indies.

Localities 806 and 807; the type from 806.

This is the common fossil *Vertigo.*

Vertigo marki n. sp. Pl. XXXVI, fig. 7.

Shell rimate, ovate, yellowish-corneous, faintly striatulate; whorls nearly 5, rather convex. Apex obtuse, but not rounded like that of *Vertigo numellata.* The inflated ridge inconspicuous, whitish, crowded close to the peristome. Aperture ovate, much longer than in *Vertigo numellata,* set with four denticles, of which the parietal lamella is the largest. The lower palatal fold denticular, smaller than that of *Vertigo numellata* and less immersed; the upper palatal fold minute; and the columellar lamella broad and low. The peristome is expanded, white, strongly thickened within, hardly notched at the upper palatal fold.

Alt. 1.9, diam. 1 mm.

Named in honor of Dr. E. L. Mark, of Harvard, Director of the Bermuda Biological Station for Research.

This species is somewhat suggestive of *V. tridentata,* but is a little slenderer, with a longer aperture, and a heavy white peristome.

Locality 806; doubtful specimens from 807.

Bifidaria rupicola Say.

One specimen each from localities 806 and 808, and several recent specimens. Dr. Pilsbry reminds us that the Bermudian form has a thicker lip than the others of this species. Cuba, Florida.

Bifidaria servilis Gld.

One specimen from locality 818, and a few recent. Cuba and other West Indian islands.

Bifidaria jamaicensis C. B. Ad.

The commonest of the recent Pupidæ, but I failed to find it fossil. Greater Antilles.

Pupoides marginatus Say.

I got one indubitable specimen from locality 809, but it went to pieces in my hands. I found only two or three recent ones. Mr. Owen Bryant, who was collecting at the same time, found a larger number. Eastern and Central North America, and some West Indian islands.

Carychium bermudense n. sp. Pl. XXXVI, figs. 11, 12.

Shell almost regularly tapering, corneous-white, imperforate, finely striate; whorls about 5, increasing regularly, those of the spire very convex, with deep sutures. Aperture quite oblique, obstructed by a small parietal and a very minute, deeply placed columellar lamella. Peristome broadly expanded and reflexed, thickened within by a white callus, with a slight groove on its front face, and developed inward to form a prominence slightly above the middle of the outer margin (near the position of the upper palatal fold in *Bifidaria*).

Alt. 1.8, diam. .9 mm.

This species is very dissimilar to the slender *Carychium jamaicense*. The shape of the aperture allies it more nearly to *Carychium exiguum* of North America, but its heavy peristome is quite its own.

It is one of the most abundant fossil species, occurring in the red earth of localities 806 and 807, and even in the sand that fills the larger shells in the sand pits.

Pœcilozonites nelsoni (Bld.).

Hyalina nelsoni Bld., Ann. Lyc. N. H. of N. Y., XI, 1875, p. 78.
P. nelsoni Pilsbry, Proc. Acad. Nat. Sci. Phila., 1888, p. 290.
P. nelsoni v. Mart., Sitzungsber. Ges. Nat. Freunde, Berlin, 1889, p. 201.

The typical form of this species is, I suppose, the large, moderately elevated form. This is represented among my specimens from locality 814, where the variation in dimensions is as follows:

Alt. 29	Diam. 39 mm.
28	37
27	41
27	40
26	35
25	39
23.5	36
23	41.5
23 (estimated)	35

The way these lay, piled together in a little pocket, compels the supposition that they lived at about the same time, and their varia-

tions in outline show what may occur in a single intergenerant colony. The specimens from locality 806 show even greater differences, of which the following are the extremes:

Alt. 34	Diam. 34 mm.
31	33
19	37
19.5	39

I should like to suggest the name *discoides*, merely as a convenient term by which to know the variation represented by the last two shells (Pl. XXXVI, fig. 4). I must say, however, that this suggestion would be unfortunate if it resulted in the division of the series obtained from locality 814. It seems to me, rather, that some physiological peculiarity has destroyed the diagnostic value of the elevation of the spire. The upper whorls differ less than the lower, and in the most elevated forms the suture of the later whorls is much below the keel of the preceding whorl, as if the slant of the spiral had been abnormally diverted downward.

Pœcilozonites nelsoni var. **callosus** n. var. Pl. XXXVI, fig. 5.

Shell smaller than the typical form, shiny, with heavy ribbed striæ, colored with a broad yellowish-brown peripheral band on a white ground. Whorls a trifle more than nine, increasing regularly and very gradually. The suture does not change its character nor become deflected from the peripheral line of the preceding whorl. The usual peripheral angle is almost obsolete. The base has a stronger angle about the umbilical perforation than is usual in the species. The peristome is greatly thickened on the inside from 1 mm. at the suture to fully 2 mm. near the columella. A prominent callosity covers the parietal wall of the aperture.

Alt. 24, diam. 33 mm.

The combination of small size and large number of whorls is characteristic. The ratio of height to diameter is more constant than in the typical form, and the tendency to produce the callosity is very marked.

Type from locality 818, others from 818 and 807.

The stability of the variety, occurring as it does in the oldest and the latest formations, is the most interesting thing about it. It is also my excuse for regarding such slight distinctions in a remarkably variable species.

I suppose the color patterns of *Pœcilozonites nelsoni* were essentially the same as those on the living *Pœcilozonites bermudensis*. For example, the type specimen of *callosus* probably had a dark brown band

on a background of a yellowish cuticular color. The depressed specimen which is figured has traces of a subperipheral band, a supraperipheral line, and radial flaming above this line. This flamed pattern appears in several of the flat specimens.

Pœcilozonites cupula n. sp. Pl. XXXVI, fig. 2.

Shell solid, dome-shaped, with somewhat flattened base, perforate, strongly striate; pale, shiny-corneous, with subsutural and subperipheral bands of darker color, and faint traces of two narrow bands on the periphery. Whorls $7\frac{2}{3}$, a little convex, increasing slowly; the last vaguely angulate at the periphery. The aperture is somewhat quadrangular on account of the straight, vertical columella and the peripheral angle. The peristome is simple, thin, with the columellar margin reflexed.

Alt. 13 Diam. 16 mm.

Locality No. 806.

Other specimens measure:

Alt. 13.5	Diam. 16.5 mm.
12.5	17
13	19
13	20
15	15.5

The last specimen has $8\frac{3}{4}$ whorls.

The type was selected as the best-preserved specimen, not as the most representative example. The majority of the specimens have a more rounded base and periphery, giving the peristome a more oval contour. The height of the shell and the absence of a keel distinguish it readily from *P. bermudensis zonatus*, and the very round dome and less angulate periphery separate it from immature specimens of *nelsoni*.

Pœcilozonites dalli n. sp. Pl. XXXVI, fig. 1.

Shell elevated, with rounded apex and convex base, perforate. Its surface is polished, with incremental lines less pronounced than those of *P. cupula;* milky-white, with a yellowish-brown band below the periphery and a line above the periphery. The first four whorls are translucent whitish. Whorls $7\frac{1}{6}$; all but the final whorl are flat as if keeled, that one has a blunt peripheral ridge, below which it is deeply rounded. The aperture is quite oblique, round-lunate. The peristome is simple, except at the columella, which it joins without an angle, but the columellar margin is reflexed, partly covering the perforation.

Alt. 8.5 Diam. 7.3 mm.

Another specimen has the height 10, diam. 7 mm., and is composed of 9 whorls. It shows more of the brown and less of the white color.

The extreme variability of *P. cupula* leaves it debatable whether this may not be a dwarf race of that species.

No specimens of this form were found last summer, and it is through the courtesy of Dr. William H. Dall of the National Museum, that I am able to describe and figure it. The specimens came to him without labels, so that we are left to conjecture their age. The slender specimen is so glossy and brightly colored that Dr. Dall doubts whether it can be a fossil, but it seems to me the simpler hypothesis to suppose that it was preserved in the sand in the same manner as the type of *P. nelsoni callosus*, which it so closely resembles in color and polish. The shell sand seems to be a complete protection from destructive agents. On this hypothesis it had originally about the color of *Pœcilozonites bermudensis*.

Pœcilozonites bermudensis Pfr.

Pilsbry, Proc. Acad. Nat. Sci. Phila., 1888, p. 289; 1889, p. 85.

The typical variety seems to be of recent origin. It is distinguished from the fossil by a less rounded upper surface, less flattened apex, larger umbilical perforation, and usually smaller number of whorls. My largest specimen I found on Rabbit Island, Harrington Sound, buried under drift sand at some time previous to the cultivation of the island. It measures alt. 13, diam. 24.5 mm. The largest and smallest living mature shells measure as follows:

Alt. 14.5	Diam. 20. mm.
14	22
10	16.5

An average fully adult specimen measures:

Alt. 11 Diam. 20 Umb. 1.7 mm.

and has a trifle more than 7 whorls.

Pœcilozonites bermudensis var. **zonatus** Verr. Pl. XXXVI, fig. 3.

This differs from the type of the species in possessing an almost uniformly curved upper contour line, an almost flat apex, and a more constricted umbilicus. The keel is distinct, as in the recent form. Whorls 7¾. The aperture is surrounded by callous thickenings as in *P. nelsoni callosus*. Alt. 13.5, diam. 23, umb. 1 mm.

Specimens come from localities Nos. 806, 808, 814, 816 and 809.

The extremes from locality No. 808 are:

Alt. 16	Diam. 22.5 mm.	
15	25	
12.5	20.5	Umb. 1 mm. wide.

Thus the smallest adult is quite equal to the average recent shells. A few selected specimens of the fossil and recent shells can hardly be distinguished. Many of the fossils do not have the callosity.

Locality 816 has great quantities of these shells so firmly cemented together that most of them are worthless as specimens. They have the peculiar spheroidal upper surface, but the perforation is wider than in the series from locality 808—not so wide, however, as in the recent. Several specimens here occur below some fragments of *Pœcilozonites nelsoni* in stalagmite, apparently showing that they were there previous to the extinction of *nelsoni*.

Broken and immature specimens from locality 808 show that the umbilicus was not much narrower than that of the recent variety until the last whorl had commenced to grow. The peculiar contour is also less noticeable prior to the last whorl. Thus in their smaller number of whorls, their less rounded contour, and their larger umbilicus, the present snails seem like an undeveloped or degenerate race of the former species.

It is possible that this fossil variety is what Pfeiffer (*Monographia*, I, p. 80) mistook for *Helix ochroleuca* Fer.

Pœcilozonites reinianus Pfr.

Helix reiniana Pfeiffer, Malak. Bl., XI, 1863, p. 1.
P. reinianus Pilsbry, Proc. Acad. Nat. Sci. Phila., 1888, p. 290; 1889, p. 85.

I found this species in every deposit examined except No. 807. Further search would doubtless show it there also. At locality 815 many fine specimens were embedded in stalagmite. They show the typical color-pattern, with the dark marks changed as usual to reddish, and the lighter ground to ivory-yellow.

The largest specimen from No. 815 measured....	Alt. 7 Diam. 13	mm.
The largest from No. 808	12	
The largest from No. 806	11.5	
The largest from the pocket at No. 814	11	
The largest recent, lent by Mr. Bryant	6	11.3
My largest recent	5	10.3

From Town Hill (locality 819) come some good specimens of var. *goodei* Pils. Examples of these measure:

Alt. 4	Diam. 10	Umb. 4	mm.
3.5	9.3	3.4	
3.7	10	4	

The species is not so uniformly common as *Pœcilozonites circumfirmatus*, but is very abundant in some places, for example, near locality 806. It would be interesting to learn whether its place in the economy of nature is different from that of the following species.

Pœcilozonites circumfirmatus Redf.

Helix circumfirmata Redfield, Ann. Lyc. N. H. of N. Y., VI, p. 16.
Pœcilozonites circumfirmatus Pilsbry, Proc. Acad. Nat. Sci. Phila., 1888, p. 291.

The modern variety comes from both formations at locality 806, and from 814 and 808. Those from locality 808 are some of them more keeled than is now usual. A series of poor specimens from No. 807 seem to bridge the gap from these to var. *discrepans*.

This species has lost less in size than the others of its genus. My largest fossil, coming from locality 808, has alt. 7, diam. 12 mm. My largest recent shell has alt. 7, diam. 11.5 mm. I think the fossils average larger than the adults of the recent shells, but it is not easy to eliminate the immature of either.

Pœcilozonites circumfirmatus var. **discrepans** Pfr.

Helix discrepans Pfr., Malak. Bl., 1864, p. 1.

Localities 807, 818 and two specimens of doubtful identity from 806. Some from 818 are extremely flat and carinate, one of them having alt. 4.8, diam. 10.5 mm. If this were the only locality that yielded the variety it would undoubtedly rank as a distinct species.

I should like to raise the question whether *Pœcilozonites discrepans* is not one of the extinct varieties. I believe it has not been treated as such heretofore, but none were found last summer any more recent than those from this sand pit.

Euconulus turbinatus n. sp. Pl. XXXVI, figs. 8, 9, 10.

Shell acutely conic, with contour very slightly convex; minutely perforate, thin, glistening yellowish-corneous, closely striate, and sculptured with microscopic spirals. Apex rounded off abruptly. Whorls 7½, not convex, narrow, the last strongly angulate at the periphery. Suture simple, hardly impressed. Base rather flat, not excavated. Aperture almost quadrangular, but with the angle at the columella indefinite. Columella slightly curved, the columellar margin narrowly reflexed. Alt. 3.4, diam. 2.8 mm. (from locality 807); diam. 3 mm. (from locality 808).

From localities Nos. 807, 806, 814, 816, 808, and 818.

The above description is a composite. The general form is described from the specimen from locality 807, but the sculpture is that of the best specimen from 806, which should, perhaps, be considered the type, and the base and aperture are taken from the specimen from 808. From 814 comes the longitudinal section of one 3.8 x 2.8 mm., with an unusually convex contour.

The genus *Euconulus* is of course, not wholly satisfactory for this species.

Zonitoides minusculus Binn.

Locality 807, and recent. Its abundance in the one deposit and absence in the others is a little surprising.

Zonitoides bristoli n. sp. Pl. XXXVI, fig. 13.

Shell resembling *Zonitoides minusculus* in general form, but much smaller, only moderately umbilicate, white, costulate, and densely sculptured with spiral lines; composed of 3 convex whorls. Apex somewhat elevated. Aperture lunate, the outer and basal margin more uniformly curved than in *Zonitoides minusculus*, and the preceding whorl cutting out a greater arc. Peristome simple, thin. Costulæ regularly spaced, coinciding with growth lines. The spaces between them crowded with fine striæ. A close, regular, spiral sculpturing crosses these lines and gives the costulæ a slightly tubercular appearance.

Alt. .7 Diam. 1.17 mm.

Named in honor of Dr. C. L. Bristol, of New York University, Associate Director of the Bermuda Biological Station for Research.

One specimen from each of localities 807 and 818; the type from the latter place.

Succinea bermudensis Pfr.

S. bermudensis Pfr., P. Z. S., 1857, p. 110; Monographia, IV, p. 817.
S. barbadensis Pilsbry, Trans. Conn. Acad., X, p. 502.

Localities 807, 806, 818, 808, 809 and recent. In the absence of alcoholic specimens of *S. barbadensis* I have given up that name and returned provisionally to the name *bermudensis*. Its presence as a fossil makes it not unlikely that it may be proved distinct from *S. barbadensis*. This is another species that was formerly larger than now. The largest fossil, from locality 808, measures alt. 13, diam. 7 mm. The largest out of 30 recent specimens lent by Mr. Bryant has alt. 12, diam. 6.3 mm.

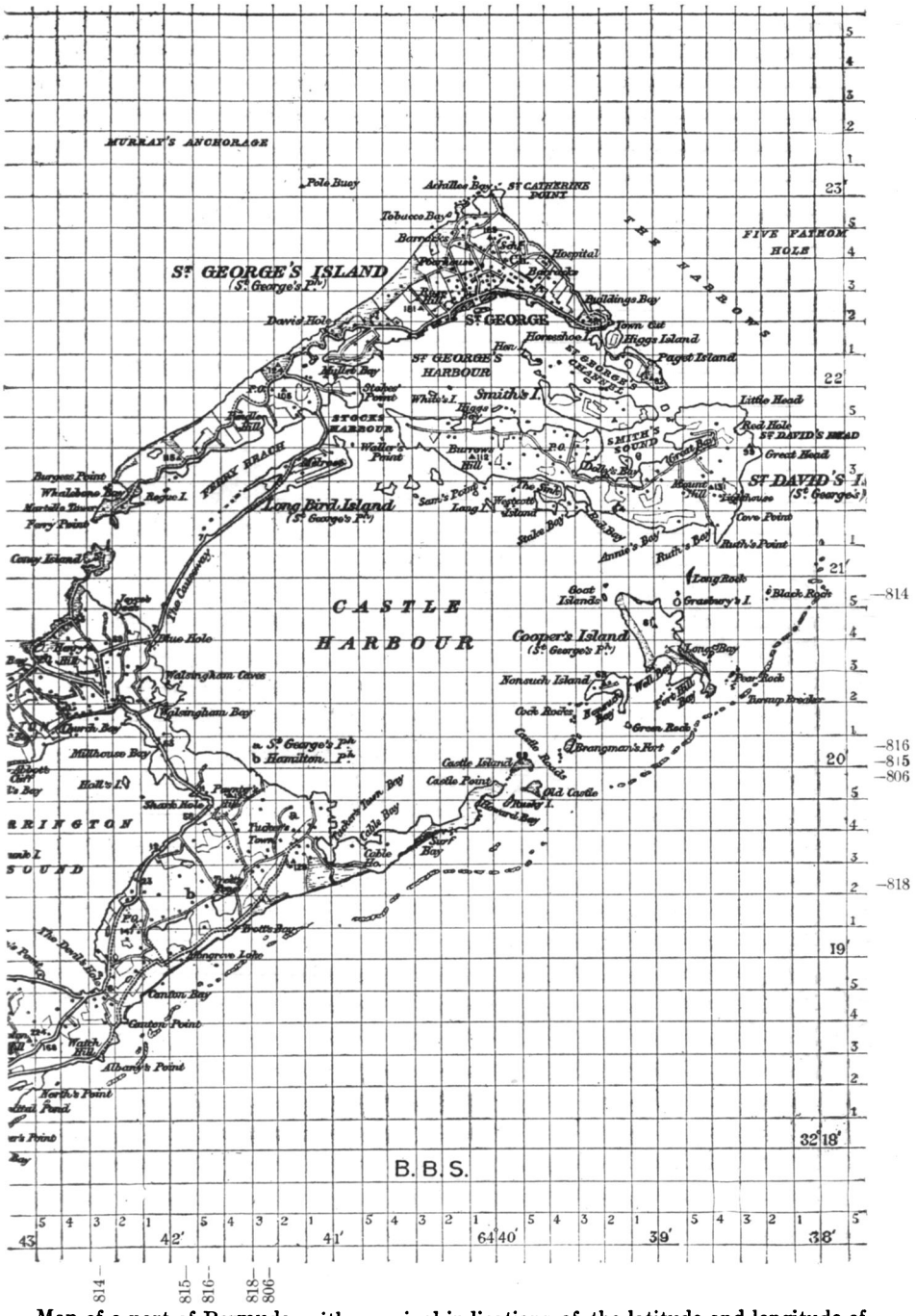
Helicina convexa Pfr.

If this species were indigenous we could expect it to be as abundant formerly as it is now. Instead of that it seems to be entirely absent from the beds I examined. The evidence seems to me strong that its real home is elsewhere.

Map 1.

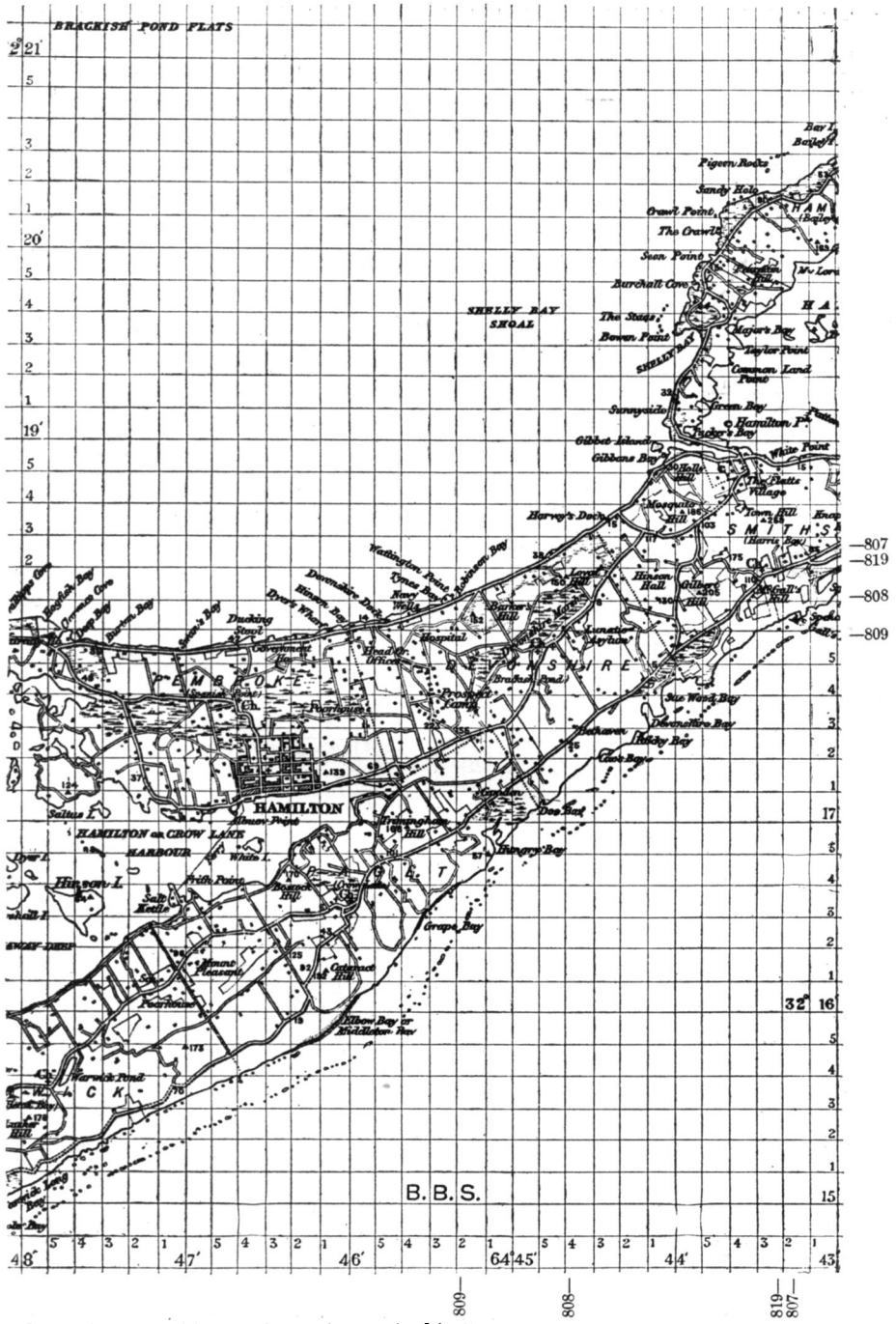
Bermuda Island.

Map 2.



Map of a part of Bermuda, with marginal indications of the latitude and longitude of collecting stations.

Map 3.

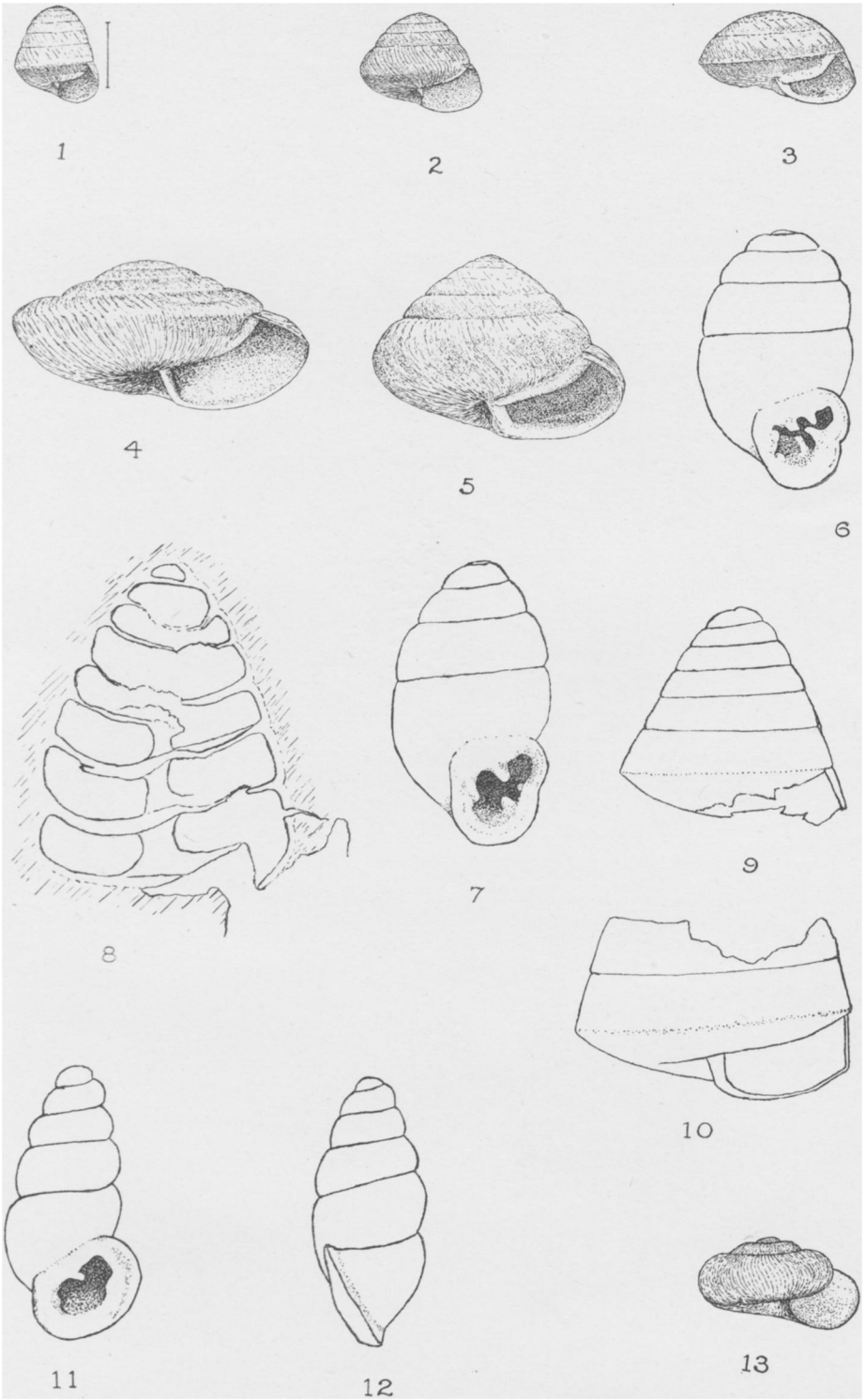


Map of a part of Bermuda, with marginal indications of the latitude and longitude of collecting stations.

REFERENCE TO PLATE XXXVI.

Figures 2 to 5 are natural size; the others are variously enlarged.

PLATE XXXVI Fig. 1.—*Pœcilozonites dalli.*
Fig. 2.—*Pœcilozonites cupula.* Locality 806.
Fig. 3.—*Pœcilozonites bermudensis zonatus.* Locality 808.
Fig. 4.—*Pœcilozonites nelsoni* form *discoides.* Locality 806.
Fig. 5.—*Pœcilozonites nelsoni callosus.* Locality 818.
Fig. 6.—*Vertigo numellata.* Locality 806.
Fig. 7.—*Vertigo marki.* Locality 806.
Fig. 8.—*Euconulus turbinatus.* Section from compact rock, locality 814.
Fig. 9.—*Euconulus turbinatus.* Locality 806.
Fig. 10.—*Euconulus turbinatus.* Locality 808.
Figs. 11, 12.—*Carychium bermudense.* Locality 806.
Fig. 13.—*Zonitoides bristoli.* Locality 818.



GULICK. FOSSIL LAND SHELLS OF BERMUDA.